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Growth and Yield of a Managed 30-Year-Old Noble Fir Plantation

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Abstract

A thinned and fertilized noble fir plantation produced 3,450 cubic feet per acre 30 years after it was planted in western Washington. More than half of this volume was in trees with diameter at breast height of 10 inches and larger. Current annual increment the last 6 years was 295 cubic feet per acre. Ornamental boughs have been harvested annually for about a 15-year period within the 30 years of the plantation's existence. The measured yield of the noble fir plantation was compared with the estimated yield of a Douglas-fir plantation of the same age; total noble fir volume was about 5 percent less than the estimated volume of Douglas-fir. The estimated value of the noble fir, including saw logs and boughs, could exceed the value of Douglas-fir grown on the same site 48 years after plantation establishment.

Keywords: Plantations, plantation growth and yield, noble fir, *Abies procera*.

Introduction

Noble fir (*Abies procera* Rehd.) is often planted in clearcuts on upper slopes in western Washington. This species will grow on a wide range of soils if ample moisture is available and will reach commercial size on relatively poor, thin, rocky soil on mesic sites (Fowells 1965).

Noble fir, like other true firs, has slow juvenile-height growth, but after this slow phase, a long period of rapid, uniform height growth can be expected (Harrington and Murray 1982). Within its natural range in western Washington, the height growth of young noble fir is less than Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) on high-quality Douglas-fir sites at low elevations. Height growth is, however, equal to or better than that of Douglas-fir on low-quality sites at high elevations (Murray 1973).

Young natural stands of noble fir can be highly productive. A 30-year-old (breast-height age) noble fir-western hemlock stand in the Washington Cascade Range, at 2,800-foot elevation, produced a volume of 7,300 cubic feet per acre (total stem, inside bark). Twenty percent of the total cubic volume was western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) (Murray 1978). Noble fir, unlike Douglas-fir, has the potential for producing both ornamental boughs and timber. Dense and beautifully colored foliage, symmetrical branching, and excellent needle retention make this conifer a valuable species for bough production (Douglass 1975). A 24-year-old, unmanaged noble fir plantation in western Washington had an estimated annual bough production of 1,720 pounds per acre each year for a 10-year period (Murray and Crawford 1982). Noble fir is grown for bough production in Denmark, where research has been done on yields of different cutting intensities and on the effect of irrigation, fertilization, and herbicides on bough yields (Bang 1979, Holstener-Jørgensen 1973, Holstener-Jørgensen and Johansen 1975).

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Europeans have had the most experience with the management of noble fir. Introduced there from the United States, this species grows well on exposed sites in Europe. Plantations in Scotland thrive in areas of full wind exposure where other species suffer from dieback (Lines 1979). In Northern Ireland, noble fir grows straight and vigorous on dry, exposed sites at relatively high elevations (Redmond 1950). Noble fir has been recommended for reforesting storm-damaged silver fir (*Abies alba* Mill.) and Norway spruce (*Picea abies* (L.) Karst.) plantations at high elevations in France. Noble fir has proved successful in trials on exposed high-elevation sites, where the species has had good stem form, height increment, and timber quality (Laurens and Kazandjian 1985). Yield of noble fir planted in Great Britain is similar to that of planted Douglas-fir (Aldhous and Low 1974). At the time of first thinning, noble fir plantations in Great Britain have about 1,200 trees per acre. Thirty-two to thirty-four years after establishment, these plantations produce total yields (standing crop plus cumulative thinning volume) of 3,000 to 8,000 cubic feet per acre, depending on yield class (Edwards and Christie 1981).

In the Pacific Northwest, little information is available on growth and yield of managed noble fir plantations. This report gives an example of yield measured from a managed noble fir plantation in western Washington and compares this yield with the simulated yield of a Douglas-fir plantation of the same age.

History and Description

The 15-acre plantation is located in western Washington in the Doty Hills of Lewis County on a gentle ridgetop (fig. 1), elevation 2,100 feet. Although the elevation is moderate, the ridge is exposed to wind, and some snow falls during winter and early spring. The maritime climate is characterized by comparatively dry, cool summers and wet, mild, cloudy winters. Average annual precipitation at the nearest weather station, about 6 miles southeast of the plantation with an elevation of 280 feet, is 53 inches (Phillips 1964). Precipitation at 2,100-foot elevation in the Doty Hills is undoubtedly greater. During the summer, the higher elevations in the Coast Range, including the Doty Hills, are frequently covered by low clouds that extend inland from the nearby Pacific Ocean; these clouds help maintain a cooler, moister climate than is found in the adjacent lowlands.

Noble fir is not native to the Doty Hills; the nearest natural stand is about 12 miles to the south of the plantation. The original stand, typical of the higher elevations of the Coast Range of southwestern Washington, consisted of Pacific silver fir (*Abies amabilis* Dougl. ex Forbes) with some associated Douglas-fir and western hemlock (Murray and Treat 1980). The area was clearcut during the early 1950's; slash was not burned. The Murren soil, a moderately deep residuum derived from basalt and volcanic ash, is well drained; of medium texture; and has a 3-inch-thick, black humus layer. Estimated site index for Douglas-fir is 110 feet at breast height age 50 years (Steinbrenner and Gehrke 1966).

About 600 2-year old, bare-root, noble fir seedlings per acre were planted during spring 1956. Fifteen years after the plantation was established, it was aerially fertilized with 200 pounds of nitrogen in the form of urea, and 2 years later it was precommercially thinned to about 500 trees per acre. Boughs have been harvested annually for a 15-year period within the 30 years of the plantation's existence; the impact of this treatment on growth is not known.

Figure 1—Noble fir plantation after thinning to 300 trees per acre.

Methods

Twenty-four years after the trees were planted, a 0.10-acre study plot was established in the plantation. At the time of installation, the plot was precommercially thinned to 300 trees per acre (fig. 1). The objective of thinning to this level was not to attain maximum production but to develop a minimum diameter at breast height (d.b.h.) of 10 inches during the next 18 years. Diameter at breast height, past height, and current height of each tree was measured. Cubic-foot volume (total stem inside bark) of each tree were estimated from a volume equation derived from stem analysis of 30 young noble fir trees in western Washington ranging in size from 2 to 13 inches d.b.h. and from 10 to 70 feet in total height.[1]

Projected yield of planted Douglas-fir from the DFSIM (Douglas-Fir SIMulator) stand simulation model (Curtis and others 1981) was compared with the actual yield of the managed noble fir plantation. This simulated Douglas-fir plantation, with a site index of 110, had the same treatment schedule as the noble fir; the Douglas-fir was fertilized with 200 pounds of nitrogen per acre at total age 17 years, thinned to 500 trees per acre at total age 19 years, and thinned to 300 trees per acre at total age 26 years.

[1] Data on file at Pacific Northwest Research Station, Forestry Sciences Laboratory, 3625 93rd Avenue, S.W., Olympia, WA 98502.

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Growth and Yield Results

Standing volume of noble fir was 3,450 cubic feet per acre 30 years after planting; more than half of this volume was in trees 10 inches in d.b.h. and larger. Diameters ranged from 7 to 12 inches at breast height; 43 percent of the trees were in the 9-inch d.b.h. class (table 1). Volume growth in the 6-year period after thinning to 300 trees per acre was 1,770 cubic feet, for a current annual increment of 295 cubic feet per acre (table 2). The average annual height growth of the 40 largest noble fir per acre was 2.3 feet 15 to 30 years after plantation establishment. This is probably the maximum annual height growth of noble fir on this site. These largest trees reached breast height an average of 7 years after planting.

Volume yield of the 30-year-old noble fir plantation was 200 cubic feet per acre less than the projected yield of a managed Douglas-fir plantation of the same age. In contrast to volume, quadratic-mean stand diameter of the two species was nearly the same (table 2). Noble fir, however, had slower early height growth than the Douglas-fir. At breast height age 5 years, noble fir top height was 13.7 feet compared with an estimated 16.0 feet for Douglas-fir. Although early height growth of noble fir was less than that estimated for Douglas-fir, height growth of Douglas-fir begins to slow earlier than that of noble fir; in the years 28 to 30 after planting, height growth of noble fir was nearly the same as that estimated for Douglas-fir (6.8 feet for noble fir and 6.9 feet for Douglas-fir).

Table 1–Stand data per acre by diameter-at-breast-height (d.b.h.) class for a noble fir plantation 30 years after planting in western Washington

D.b.h. class	Trees	Average height	Volume[a]
Inch	*Number*	*Feet*	*Cubic feet*
7	10	43	50
8	40	49	300
9	130	52	1,300
10	60	55	780
11	50	57	820
12	10	58	200
Stand total	300	--	3,450

[a] Cubic volume for total stem, inside bark.

Table 2—Data per acre by age for a noble fir plantation and a simulated Douglas-fir plantation, western Washington

Plantation	Total age	Breast height age	Years from planting	Treatment	H_{40}[a]	Trees	Dg[b]	Volume
	Years	*Years*			*Feet*	*Number*	*Inches*	*Cubic feet*
Noble fir								
	13	5	11	--	13.7	600	--	--
	16	8	14	--	21.0	600	--	--
	17	9	15	Fert[c]	23.3	600	--	--
	19	11	17	Thin	28.2	500	--	--
	23	15	21	--	37.6	500	--	--
	26	18	24	Thin	44.7	300	7.6	1680
	29	21	27	--	51.0	300	--	--
	32	24	30	--	57.8	300	9.5	3450
	50	42	48	--	99.2[d]	260[d]	13.1[d]	9700[d]
Simulated Douglas-fir[e]								
	13	5	11	--	16.0	--	--	--
	16	8	14	--	24.1	--	--	--
	17	9	15	Fert[c]	26.9	--	--	--
	19	11	17	Thin	32.9	500	--	--
	23	15	21	--	45.2	495	--	--
	26	18	24	Thin	53.4	300	7.4	1844
	29	21	27	--	60.8	298	--	--
	32	24	30	--	67.7	294	9.4	3650
	50	42	48	--	101.2	258	13.1	9045

[a] H_{40} = Average height of the 40 largest trees per acre (top height).
[b] Dg = Diameter-at-breast-height of tree with mean basal area (quadratic mean).
[c] Fert = Fertilized with 200 pounds of nitrogen per acre.
[d] Estimated values. The probable mortality of thinned noble fir is unknown. For comparison, the number of surviving noble fir at age 50 years was chosen to be near the number of surviving Douglas-fir at age 50 years. Although the number of trees per acre, Dg, and H_{40} of noble fir and Douglas-fir are similar at age 50 years, noble fir has greater cubic volume per acre as a result of better tree form.
[e] Douglas-fir data per acre estimated from Douglas-Fir SIMulator (DFSIM) (Curtis and others, 1981).

Discussion

This study has shown that 30 years after planting, a managed noble fir plantation can provide a bough harvest for 15 years as well as produce a cubic-foot volume within about 5 percent of that estimated for planted Douglas-fir. How does the estimated yield of this managed noble fir plantation 48 years after planting (50 years from seed) compare with the estimated yield of Douglas-fir of the same age? An estimate of noble fir yield can only be guessed, but the assumption that noble fir yield could equal or exceed estimated yield of planted Douglas-fir is reasonable. If dominant noble fir continue to maintain an average annual height growth of 2.3 feet during the next 18 years, average noble fir dominant height will be only 2.0 feet less than the estimated dominant height of Douglas-fir (table 2). An average annual noble fir diameter growth equal to that of Douglas-fir (0.20 inch) will give an equal quadratic-mean stand diameter at breast height for the two species at stand age 50 years. Average diameter growth of this magnitude does not seem unreasonable for thinned noble fir. Expected minimum size of the noble fir would be 10 inches in d.b.h. The regime described for this plantation is not the only one possible. Based on experience in Great Britain, total yield can be increased if stocking is increased. Noble fir appears to have narrower crowns than Douglas-fir, and growing noble fir in denser stands than Douglas-fir may be possible.

Factors other than yield, however, need to be considered when a species is selected for timber production. These factors include length of rotation and value of the products. If noble fir is grown on long rotations, slow early height growth may not be a problem. The long period of rapid height growth allows noble fir to catch up with or surpass other conifers that have an earlier slowing of height growth.

Income from bough harvest helps increase the value of noble fir. A sample of noble fir bough values ranged from $20 to $300 per ton in 1987, depending on location and difficulty of harvest.[2] With an assumed annual bough harvest of 0.5 ton per acre, the total value of the boughs per acre at 1987 prices for a 15-year period ranged from $150 ($20 per ton) to $2,250 ($300 per ton) for the 15-acre plantation. This shows that bough production can provide substantial values, not only to help pay for plantation establishment and management but also to provide early income.

The total value of the noble fir plantation 48 years after planting will depend on the value of noble fir logs. For example, the average value of noble fir number 3 saw logs ($224.73 per thousand board feet) during the period from 1975 to 1985 was only 3 percent less than the value of Douglas-fir ($231.55 per thousand board feet) of the same log grade (Warren 1986). If noble fir saw logs in the future maintain a value similar to that of Douglas-fir, the total value of this noble fir plantation 48 years after planting, including bough harvest, could exceed the value of Douglas-fir grown on the same site.

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[2] One private landowner in western Washington sold noble fir boughs to cutters for $260 to $300 per ton. Twenty dollars per ton was the selling price for boughs from a noble fir plantation on the Soleduck District, Olympic National Forest.

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